Rating Places: a Statistical Exploration

A proper oasis of friendliness in grim north: that's Burnley
(*The Times*, 13 October 2016, p.23)

Cambridge gets a first for quality of life
(*The Times*, 16 November 2016, p.24)

ABSTRACT. The UK media frequently publish articles reporting on research that rates places on various criteria, with indices that can be structured into league tables. Such indices are frequently based on statistical procedures that over-simplify the differences between places, assuming that averaging data on a number of different criteria presents a valid representation of a general pattern. After a critique of such methods this paper suggests an alternative procedure and applies it to the data used for the recent production of a *UK Prosperity Index*. It shows that the geographies of the forty-three separate variables deployed in producing that index are more complex than can reasonably be assumed.

The UK media frequently carries headlines such as these two. They are derived from exercises, most of them conducted by either think-tanks or commercial organisations,[1] devised to depict variations across the country in various aspects of economic and social wellbeing, from which the media constructs 'league tables' identifying the 'best and worst performing places'. (Thus, for example, the first of the items identified Bristol as 'best for business', Shetland as 'safest' and Winchester as 'richest'; West Somerset residents were the 'most optimistic'.) Production of such league tables is not foremost in the goals of those producing the data on which the headlines are based, although the publicity that such representations bring is probably not unwelcome.

The *UK Prosperity Index*, the basis for the first quote above, was designed by the Legatum Institute (2016) to identify why the UK does not perform better in international comparisons on prosperity levels. Some places perform less well than others and bring down the national average; if they matched the performance of the best, then the UK would perform better internationally, because the potential of all of its residents was being fulfilled. The second of the sources quoted above – the Grant Thornton *UK Vibrant Economy Index* – was designed as a 'new way to measure the success of the nation' in order to provide businesses with an understanding of their local economy, place-makers with an overview of the strengths and opportunities, challenges and weaknesses of individual places, and citizens with an indication about their place's situation so that they could contribute to discussions about shaping its future.[2]

Those two indices, and others like them, are constructed by mining available data from a variety of sources to portray different aspects of the country's economic and social geography. These data sets differentiate places (in most cases local authorities) on a range of available indicators chosen to represent the selected constructs – such as the local business

environment – believed to reflect the underlying sources of wellbeing and illfare. Those separate indices are then combined into a single composite index – identifying the places that are most and least prosperous, or with the most or least vibrant economies, for example – that gives a synoptic view of the country's economic and social geography. Such exercises can be criticised on a variety of grounds, not least the quality of the data deployed (especially those derived from sample and other surveys) and the areal units to which they refer: UK local authorities vary extensively in their size and nature, for example.[3] This paper accepts those imperfections, however, and focuses on the procedures used in the data analyses, in particular on the validity and robustness of their findings.

Most of the reported place rankings – as far as can be told – are based on relatively simple statistical procedures and assume that collapsing a vast amount of data into a single index – usually by some averaging procedure – will identify a general pattern that provides a valuable synthetic overview of, for example, the country's prosperity. Are such assumptions and the composite indices valid representations? This paper addresses that question, using as its case study the Legatum Institute's (2016) *UK Prosperity Index* for which not only was the procedure used published but in addition all of the data were made freely available on the Institute's website.

INDEX CONSTRUCTION METHODS AND THEIR ASSUMPTIONS

Most of these rating exercises are based on a common methodology, involving the following steps:

1. A number of separate domains within the overall subject area is identified. If the main interest is in variations in the business environment then separate domains covering, for example, educational provision in places and the volume of investment in the local infrastructure might be selected.
2. For each domain, a number of variables representing different aspects of the concept is selected – with educational provision, for example, they might include the percentage of schools rated outstanding by OFSTED inspectors, the percentage of students achieving five or more A-C grades at GCSE, and the percentage of students who proceed from the area's schools into higher education.
3. The original data for the selected variables are transformed to a common scale – e.g. from 0 (the worst performing) to 100 (the best performing).
4. An average score for each area over all variables in each domain is obtained – such as the arithmetic mean.
5. Those mean values are used to rank order the areas in their performance within that domain.
6. The mean value for each area across all of the domains is obtained (i.e. the mean of the means) to produce an overall evaluation of its position.

Although apparently straightforward, this methodology incorporates a number of (often implicit) assumptions about the variables and domains; their acceptance can have substantial impacts on the results obtained, and hence the interpretation.

Means and their Meaning

One assumption underpinning such exercises is that all variables within a domain will be telling approximately the same story – it is implicit that an area which ranks highly on one variable will also rank highly on the others. If the correlation between the rankings is very

large it could be argued that only one of the variables is necessary to represent the domain. That is rarely the case, however, because of local circumstances; an area with few outstanding schools may nevertheless get good GCSE results, for example. By including a number of variables for a domain it is assumed (again, in almost all cases implicitly) that averaging will smooth-out those local variations and give a better overall picture than might be achieved if just one variable were included.

But what if those assumptions are invalid and all of the variables selected to represent a particular domain are not highly inter-correlated, so that the areas which come high on one of them rank much lower on others? In such a case, the standard averaging procedure may produce a very misleading result. Take a hypothetical set of 26 areas – A-Z – for which measurements on four variables have been obtained. Areas A-C may occupy the first three places on two of those variables and areas X-Z the bottom three places, but on the other two variables A-C occupy the bottom three places and X-Z the top three. If their scores across all four variables are averaged, areas A-C and X-Z may well be placed in the centre of the distribution (i.e. places 11-16), which would be entirely misleading; occupying the central positions would imply that they are 'average' places when they are not – they are well-above-average on some variables and well-below-average on the others.

In such a situation the domain cannot validly be reduced to a single – average – dimension; instead it comprises two (or more) separate dimensions. Whether that is the case is rarely explored, however; the analyses assume that all variables within a domain are closely correlated and so can be reduced to a meaningful mean!

An enhanced methodology would remove these assumptions on which indices of wellbeing or whatever, and the associated league tables, are constructed. It would make greater use of the richness of the data and provide a more nuanced – although almost certainly less over-simplified – appreciation of the patterns in the data. The next sections of this paper deploy such a methodology, using the data underlying a recently-constructed *UK Prosperity Index*.

THE *UK PROSPERITY INDEX*

The Legatum Institute's *UK Prosperity Index* was produced, according to the head of the team involved, to show why the country was being held back in its promotion of wellbeing – it was ranked only 14th in its *Global Prosperity Index* because the 'opportunity to flourish does not reach all citizens' (Legatum Institute, 2016, p.2). The reason adduced for that failure was that the 'opportunity to flourish' was 'most lacking in urban areas', where there was a 'clear failure by every level of local, national, and supranational government to deliver' – a failure reflected in high levels of voting support for Leave in the 2016 EU referendum in those parts of the country where local governments performed badly on the *Index*. Their identification led to 'a rallying call for a new agenda of localism capable of driving wealth creation, sparking aspiration, and supporting fulfilment. … it points to the power of strong social capital in communities to deliver transformation'.

Construction of the *UK Prosperity Index* involved analysis of forty-three different variables (listed in the appendix) over seven domains: Economic Quality; Business Environment; Educational Attainment; Health; Safety & Security; Social Capital; and Natural Environment. Each variable was standardised to range between 0 (the worst performing) and 1 (the best performing). The arithmetical average (mean) value was derived for each of the 389 local authorities across all variables within each domain, to produce seven separate orderings, one

per domain. Finally, those seven mean values were summed across the 389 authorities and the mean of those means obtained to produce an overall average score for each place across all domains. How valid were those seven domain mean values, and then the mean of those means, as representations of the spatial variability of conditions across the UK's local authorities – accepting that the variables chosen for each domain are valid representations of the concept?

Principal Components Factor Analyses

The method used here to evaluate that validity is principal components factor analysis, a standard data reduction procedure that explores the inter-correlations among variables from which it creates new composite variables, as in the classic early study of variations across British towns (Moser and Scott, 1961). It takes the matrix of correlations across a group of variables, such as the seven measuring economic quality in the *UK Prosperity Index*, and creates a new variable occupying the average position within that group. (For diagrammatic illustrations of this, see Johnston, 1978, chapter 5.) The correlation between each of the original variables and the new construct is derived. Termed the factor (or component) loading, this can vary between -1.0 and +1.0 and can be interpreted in the same way as a correlation coefficient; the larger the squared value the closer the relationship between the original variable and the new – average – construct (so a loading of 0.72 indicates that 52 per cent of the variation in the original variable can be accounted for by the new construct). Also computed are the factor scores for the observation units (the local authorities in this example) on that average variable; these combine the original values on all of the variables weighted according to their loadings, so that the variables most closely correlated with the factor have the greatest impact on the calculation of the scores on the new average variable.

Having isolated the first factor, the analysis then extracts a second, orthogonal to the first (i.e. they are uncorrelated). This occupies the average position within those parts of the residual variation from the first factor – with loadings and scores calculated as before. Further factors are then computed in the same way: eventually the number extracted will be the same as the number of original variables but in most cases substantial inter-correlations among at least some of the original variables mean that the later factors account for little of the variation and can be ignored. The amount of variation accounted for by each factor is termed its eigenvalue, which is the sum of the squared loadings on that factor, and the relative size of each factor can be indicated by expressing the eigenvalue as a percentage of the number of variables in the analysis. The larger that percentage the closer most, if not all, of the variables are to the average position.

If the first factor does not account for a substantial percentage of the variation across all of the variables in the domain analysts will then normally inspect the second, and perhaps other, factors. A widely-deployed rule-of-thumb is that all factors with an eigenvalue greater than 1.0 will be considered worthy of consideration, but this will vary according to circumstances, not least the number of variables – an eigenvalue of 1.0 encompasses a larger percentage of the variation if four variables are being analysed than if there are twelve. When the number of factors to be interpreted is determined, it is normal to rotate them to obtain simple structure – a situation where each variable has as large a loading as possible on just one of the factors, providing clarity on which of the original variables are closely related to the newly-constructed ones. Rotations may be either orthogonal (the zero correlations between the factors are maintained) or oblique (the factors themselves are correlated).

FACTOR ANALYSES OF THE SEVEN UK PROSPERITY INDEX DOMAINS:

The first stage in applying principal components factor analysis to the *UK Prosperity Index* data involved fitting a single-factor solution to the matrix of correlations for each of the seven domains; if the underlying assumption of the approach is correct, then within each domain all of the selected variables should have high loadings on the first factor. The loadings on those factors, together with their eigenvalues and their percentages of the variation accounted for, are in Table 1. From this, the clear conclusion is that for none of the domains is there an average position across all of its variables that accounts for a substantial proportion of the variation; indeed in only one case – for Business Environment – does the first factor account for even 50 per cent of the variation. Within each domain the variables chosen are not all closely inter-related; or, alternatively, how a local authority rates on one of them is not necessarily a good indicator of how it rates on one or more of the others. There is more than one geography underpinning the patterns within the data set – not a single common pattern which construction of an index for each domain using the mean value assumes.

This conclusion is further appreciated by inspection of the factor loadings in Table 1. For each domain, although some variables have high loadings, others do not. There is no straightforward rule of thumb for assessing whether a loading is large or not, but recall that the square of each loading indicates the proportion of the variation in the variable concerned that is associated with the average pattern identified by the factor. As the square root of 0.50 is 0.707, therefore, any loading less than 0.71 indicates that more of the variation is not associated with the factor than is; for two-thirds of the variation to be associated with the factor, a loading would have to be 0.82. Thus, for example, among the seven variables selected to represent an area's economic quality, whereas three – unemployment, long term unemployment, and child poverty – have high loadings, the other four do not. The geographies of unemployment, long term unemployment, and child poverty vary in similar ways across the 389 local authorities, but those of living comfortably, job satisfaction, median annual income, and GVA growth do not. Combining all seven by a simple averaging process therefore confuses several different geographies. Similar situations apply to all other domains. Indeed, some variables have negative loadings; within the Business Environment domain, for example, as the quality of broadband provision increases (the two variables with the highest positive loadings) the rate of business survival (perhaps surprisingly) declines.

At this first stage in the analysis, therefore, it is clear that the variables chosen to represent each of the seven domains are not closely correlated: creating an average variable for each domain by summing the scores across all variables and then obtaining the mean thus combines unlike things and the resulting index has little validity.

Exploring the Multi-Dimensional Structure of Each Domain

Following that conclusion, the second stage of the reanalysis involves undertaking more extensive principal components factor analyses of each of the seven data matrices, exploring whether they should be represented by several separate dimensions rather than one. For this, the eigenvalues greater than 1.0 rule-of-thumb was applied, with the results shown in Table 2. Two of the seven (Business Environment and Safety & Security) resulted in a single dimension only being extracted, but even with them the variation accounted for was no more than 50 per cent of the total. Four others had two separate dimensions with the total variation accounted for exceeding 50 per cent in each case – although for none did it exceed 75 per cent. Finally, for Social Capital three separate dimensions with eigenvalues greater than 1.0

were extracted – which together accounted for only 57.5 per cent of the variation. With all seven domains, therefore, much of the variation across the 389 local authorities in the individual variables was unrelated to the general patterns identified by the factors: the pictures regarding patterns of prosperity and its components across the UK were far from unidimensional.

To explore further the multi-dimensional picture, a two-factor solution was obtained for each of the domains except Social Capital, for which a three-factor solution was extracted. The resulting factors were then obliquely rotated to obtain the closest fit to a simple structure. The resultant loadings are in Table 3.

Looking at the factor loadings within each domain in turn, those for *Economic Quality* involve one very clear pattern and one much less so. The high loadings for the two unemployment measures and that of child poverty show that areas with high unemployment also had high child poverty levels and vice versa – and additionally a loading of 0.67 suggested that those areas had relatively high proportions of their populations reporting that they were living comfortably on their current income, which appears counter-intuitive. None of the other variables loaded substantially on that factor, however. The relatively low loadings on the second factor suggest that places with relatively high incomes also had high growth of Gross Value Added – but the negative loading for job satisfaction suggests that in places with high incomes people tended to be dissatisfied with their jobs, and vice versa!

For the *Business Environment* domain the first factor combines the two variables representing broadband speed and shows that they were not strongly related to either business creation and survival or logistics (transport infrastructure) provision, with the business creation and survival variables loading relatively weakly on the second factor; places with good broadband provision were not also those where businesses were being created in great numbers and then prospering. For *Educational Attainment* there was a clear bifurcation with two very distinct factors. The first combines the two representing GCSE performance and the second links the percentage of adults with no qualifications to the truancy rate; an expected link between GCSE success rates and the percentage with no qualifications was absent – how well students were doing in a place was not related to how well the adults living there had performed when in education.

For the *Health* domain several variables lacked a substantial loading on either factor. The first linked life expectancy rates with mortality from two of the major causes (cancer and premature cardiovascular), with weaker links to obesity levels, health satisfaction and smoking rates: the scores for the local authorities on this factor would arrange them according to their mortality/morbidity situations. The only substantial loading on the second factor is for anxiety, with a smaller one for wellbeing: places where people are most anxious tend to be those where people feel that their life is not worthwhile (that variable is scored, like all others, from the places with the worst ratings to those with the best, so places full of anxious people tend also to have dissatisfied people). But, because the two factors are separate, anxiety and dissatisfaction levels are not related to those of physical health. (This does not necessarily imply that people in poor health are not anxious, only that places with lots of people in poor health are not necessarily those with the highest anxiety levels.)

With regard to *Safety & Security*, the two high loadings on the first factor relate to crime rates; the scores arrange local authorities on a combination of the two. Road deaths is the only variable with a high loading on the second factor: they have a different geography to that

of violent crime and thefts – although the smaller, and negative, loadings suggest that where road deaths are numerous people feel less safe either walking alone at night or more generally in their community. For the *Natural Environment* high loadings on the first factor (two of them negative) show that places with high levels of air pollution generate less waste and also that less of that generated is either sent to landfill or not incinerated; local authorities with unhealthy air are less effective at waste disposal. Perhaps not surprisingly, those three variables are not related to the proportion of the local authority's land that is protected; that variable loads heavily on the second factor.

Finally the three factors for the *Social Capital* domain variables separate out different aspects of local society. Two high loadings only on the first factor separate out those areas with strong communities – where people say that they can rely on friends and family for needed support – from those where that is (relatively) absent. The second factor has no very high loadings; the two relatively large ones suggest that areas with high housing costs also have high recycling rates.[4] Similarly, the loadings on the third factor provide no very clear picture, relating areas with high volunteering rates to those where housing is not very affordable, and vice versa. But neither voter turnout nor social trust is strongly linked to any of those three patterns:[5] there are many complex geographies to social capital in the UK – certainly not one.

These seven factor analyses, alongside the earlier discussion of the first factors only, lead to two clear conclusions. First, the evidence suggests that combining the values for all of the variables selected to represent each domain and then taking the mean score to represent the relative position of each local authority on that domain provides a very misleading picture. Secondly, because in none of the seven domains does the first factor account for more than half of the variation in the geographies of the selected variables it is very likely that within each domain there are at least two separate dimensions, two geographies (of mortality/morbidity and of anxiety/life dissatisfaction within the Health domain, for example) that have different patterns.

This is illustrated by the scatter diagram in Figure 1; each local authority's score on the first Health factor is on the horizontal axis and its score on the second Health factor is on the vertical axis. If places with good health (the positive end of the first factor) also had high percentages of their population feeling well (the positive end of the second factor) and vice versa, most of the points would lie on a diagonal from the bottom left to the top right of the graph. That there is no such relationship indicates that the two geographies are entirely separate. The top five authorities – i.e. the healthiest – on the first factor are Kensington & Chelsea, Richmond upon Thames, Winchester, Camden, and Chiltern, whereas the bottom five – the least healthy – are all in Scotland (Glasgow, North Lanarkshire, Inverclyde, West Dunbartonshire, and Dundee). None of those ten authorities appears in the comparable lists for the second factor. The five places with the highest positive scores – where people are least anxious and dissatisfied – are Eilean Siar, Fermanagh & Omagh, Richmondshire, the Orkney Islands, and Mid Ulster , whereas those with the highest negative scores – containing the most anxious and dissatisfied populations – are Islington, Camden, Newcastle upon Tyne, Hackney and Westminster.

A Single Prosperity Index?

The next stage in the Legatum Institute's analysis involved combining the index scores (i.e. the mean across all of a domain's variables) for each of the seven domains into a single

index, by summing the seven scores for each local authority and taking the mean. Those mean values were presented as the overall *prosperity index* for each place.

The same implicit assumptions regarding the validity of such means apply to this stage also. If those seven indices all had very similar geographies (the assumption underpinning the Legatum Institute's methodology), then combining them into a single index would be a straightforward simplification exercise. But a factor analysis of their seven indices – one for each domain – suggests otherwise. A single-factor solution (the first column of Table 4) has relatively high loadings for three of the indices – Economic Quality, Education, and Health – with smaller ones for two more (Safety & Security, and Social Capital) and negligible ones for the final two (Business Environment, and Natural Environment). Even their seven indices – each of which, according to the analyses above, is internally incoherent, combining variables that are, at best, only weakly correlated – don't readily collapse to a single overall portrait of the country's economic and social geography for the separate domains.

Further analysis of those seven mean values identified a three-factor solution, each of which had high loadings for at least one of the domain indices. These (the right-hand columns of Table 4) suggest that – if we accept for the moment that each of the seven domain indices has statistical validity – there are three major dimensions to the country's geography. The first brings together the Economic Quality, Education, and Health domains – arranging the local authorities on a continuum from those with healthy and well-educated populations with low unemployment at one extreme, and those with (relatively) unhealthy, poorly-educated populations with high unemployment at the other. The second links the maps of Safety & Security, Social Capital, and Business Environment. And the third shows that the Natural Environment map has little in common with any of the other six.

But, as the previous analyses here have shown, the internal validity of those domain indices is doubtful – each combines maps that have very different patterns and the averages obtained have little value; they represent chaotic conceptions rather than coherent concepts (Sayer, 1992). What of the larger number of maps for each domain obtained through the factor analyses? The scores for each local authority on each of those fifteen factors were themselves subjected to a factor analysis, the first unrotated factor of which accounted for only 26 per cent of the variance; further, only one of the fifteen had a loading of more than 0.80 on the first factor, with just one other exceeding +/-0.70 (Table 5). The unrotated four-factor solution accounted for 69 per cent of the variation, but the pattern of rotated loadings did not suggest great clarity. Five of the fifteen did not have a single loading exceeding 0.7, which would indicate that at least half of the spatial variation in their scores had something in common with at least one of the other maps, and only four loadings had loadings greater than +/-0.8.

Inspection of the loadings (Table 5) indicates that the first factor links the first Safety & Security dimension negatively with the first for the Business Environment. Places where people felt relatively secure tended to be those with relatively poor broadband provision (almost certainly rural areas), and vice versa. The second factor links the first Health dimension and the third Social Capital dimension together positively, and negatively with the second Education and Business Environment dimensions: places with healthy populations tended also to have high volunteering rates, relatively few with no educational qualifications and better business survival rates. The third factor groups two dimensions showing that places with high levels of family and friend social capital also produce good performances at

GCSE. And the fourth factor shows that areas with lots of protected land tend to be those with fewest violent crimes and thefts (again, undoubtedly picking out relatively rural areas).

Do these four factors in any way encapsulate the same basic geographies as the seven indices produced by the Legatum Institute, along with their combined index? Table 6 shows the correlations between all pairs, and suggests a clear negative conclusion. In two cases there is a close correlation between one of the 'super-factors' (those identified in Table 5) and one of the Institute's indices. The latter's Safety & Security index is closely linked to the first factor (which combined aspects of safety with the business environment) – basically both are picking out rural areas. Of the ten areas with the highest values on the Safety & Security Legatum index, nine are in Scotland and only one (South Gloucestershire) in England; and of the ten with the poorest broadband provision (the first Business Environment factor) seven are in northern Scotland and three in west Wales. There is also a high correlation between the second factor identified in Table 5 and the Legatum Health index: they both arrange the local authorities on a continuum according to their populations' healthiness.

The final column of Table 6 shows correlations between the four factors identified in Table 5 and the Legatum Institute's combined UK prosperity index. Three are small (the largest of them – 0.48 – shows that only 23 per cent of one geography is linked to the other) and the largest is only -0.74.

The overwhelming conclusion to be drawn from these reanalyses of the Legatum Institute's data is that to reduce the forty-three separate variables firstly to seven domain indices, simply by taking the mean value across each of the domain's variables, and then to combine those seven means into a single index using the same procedure does not compress forty-three separate maps into a single representation that has considerable validity as a meaningful general picture of the United Kingdom's business environment. Although there are some commonalities among groups within those forty-three maps the UK's economic and social landscape is not only significantly over-simplified by reducing them to one, it is also a misrepresentation. That single map combines disparate elements in a way that confuses different things rather than highlights their common elements. Creating several maps, as in the factor analyses reported here, focuses more clearly on the common elements among some of those maps – but even so the dominant conclusion is that the differences are greater than the commonalities.

Does Greater Statistical Sophistication Change the General Picture?

A major purpose of publishing the *UK Prosperity Index* is to identify 'best practice' areas, where prosperity is above average (indeed, the Legatum Institute refers to places with a 'prosperity surplus' – 2016, p.16) and which can act as paradigm cases that other local authorities might emulate in promoting their residents' wellbeing. But does how the analysis is conducted influence which provide those good practicemodels?

To address that question Tables 7 and 8 identify the places with the top and bottom ten scores on a number of the individual and combined indices. Table 7 looks at the four variables included in the Education domain, two of which (relating to GCSE performance) loaded heavily on one factor and very weakly on another, with the reverse for the other two variables (adults with no qualifications and truancy rates). Data in the first block shows that nine of the ten local authorities with the best GCSE performances were in Wales, the only exception being East Renfrewshire. And yet only one of those ten local authorities – East Renfrewshire

– is also in the top ten for performance in the core GCSE subjects. It is almost the same for the bottom ten: only four of those with the worst general GCSE performance (Knowsley – the worst, Blackpool, Bradford and Clackmannanshire) also appear in that list for the core subjects. And yet those two variables are apparently highly correlated, with strong loadings on the first factor reported in Table 3.[6] Indeed, none of the nine Welsh local authorities that scored very highly on GCSE performance across all subjects also did so when the subjects included were restricted to the core disciplines.

Turning to the other two variables, which loaded highly on the second factor (Table 3),[7] none of the ten places with the best records on the first variable (i.e. with fewest adults having no qualifications) also appeared in the list of places with the lowest truancy rates. Similarly, the two lists of ten places with the poorest performance on those two variables were totally different.

What happens when composite indices are created? The first list in the bottom block of Table 7 gives the ten best and worst performing places on the Legatum Institute's combined Education index. Only one – East Renfrewshire – appears on two of the lists of the best-performing places on the four separate variables; seven appear on just one (five on the second variable and two on the fourth); and two – Sutton and Chiltern – appear in none of the lists in the top part of the table. The other two lists use the scores on the two separate factors; the first – which combines performance on the two GCSE measures – is dominated by places that came in the top ten on performance in the core GCSE subjects (four of them in Northern Ireland, none of which appear in the Legatum Institute's combined index list); the top ten on the second factor – which combines performance on adult qualification levels and truancy rates – contains four places in the top ten for adult qualifications, three in the top ten for truancy, and the other three are in neither list.

Although the Legatum Institute combined the indices for its seven domains into a single overall *UK Prosperity Index*, the factor analysis of those seven indices separated them into three different constructs. The latter three lists differ almost completely. The top ten places on the first factor – with high loadings on Economic Quality, Business Environment, and Health (Table 8) – are all part of London's commuter belt, only one of them within Greater London county. All ten in the second list (with high loadings for Safety & Security and for Social Capital) are London boroughs; and, with the exception of Tower Hamlets and Barrow-in-Furness, eight of the ten places in the list for the third factor (Natural Environment) are in either southeast or southwest England.[8] The top ten on the composite *UK Prosperity Index* contains five of the places in the top ten for the first factor, and five others that appear in none of the three other lists. (The bottom ten on the composite index includes eight of the places in the bottom ten for the first factor.)

DISCUSSION AND CONCLUSIONS

The presentation of differences across the United Kingdom on a whole range of economic, social, cultural and political characteristics is popular with the media, allowing them to produce league tables of the 'best' and 'worst' places. (On the validity of many of those league tables regarding school and university performance see, for example, Goldstein and Spiegelhalter, 1996; Goldstein and Leckie, 2008; Cheng and Marsh, 2010). Generation of such league tables is not necessarily the prime goal of those who produced the data on which they are based – although they often highlight the differences between places as indicative of variations that should be reduced.

Such media representations frequently simplify the messages being conveyed by the data, but it is generally assumed that the data themselves are valid and present robust pictures of variations across the country. The argument presented here challenges that assumption, however. Many of the representations are based on unsound, over-simplified, statistical procedures – although the goal is simplification, finding the general patterns within a complex data set, the adopted procedure (based perhaps on nothing more than the calculation of simple averages) may over-simplify, to the extent that they mis-represent. That argument was tested using the published data set on which one such recent representation of spatial diversity within the UK was based – the Legatum Institute's *UK Prosperity Index*. This divided prosperity's components into seven separate domains, for each of which a number of different descriptive variables was selected, and devised a composite index for each before concluding with a single, composite of those composites. Analyses designed to assess whether those composite indices have statistical validity showed that they do not. The variables selected for each domain do not have the same general geography, the same patterns of high and low values across the UK's 389 local authorities. Instead they comprise two, or even more, separate geographies and compressing them into a single pattern – let alone a single pattern combining the seven components – results in a geography, an identification of the 'best' and 'worst' performing places, that bears little resemblance to those complex patterns.

The world – as Rose (2016) has argued – values sameness, and pays a lot of attention to averages but, as he so clearly shows, many (if not most) averages are meaningless; there are no average people, just different people who vary around the average. Extending his argument to the data analysed here, there are no average places (local authorities) just many different places that vary around an average. Acceptance of that case does not imply a counsel of despair, however. As Goldthorpe (2016) has just as convincingly argued, any population science must seek the general within the particular – but it must not deploy methods that so over-generalise that they misrepresent. Davies (2017) has recently pointed to the growing distrust of statistical analyses within the population, and of their interpretation by (often self-defined) 'experts'. Their replacement by commercially-collected 'big data' of often dubious reliability is creating a 'crisis of statistics', calling for a 'new digital elite [able] to identify the facts, projection and truth amid the rushing stream of data'.

That is the message of the reanalyses of the Legatum Institute data here; its original analyses of selected indicators from that 'rushing stream' not only accepts the selected measures, and the places to which they refer, as valid indicators of aspects of the UK's prosperity but – as the reanalyses have shown – abuses those data, drawing conclusions that distort, through wrongly-applied statistical procedures, any underlying patterns. Reducing forty-three different geographies of the UK to first seven and then just one not only over-simplifies the situation, it misrepresents it. Slightly greater statistical sophistication is needed to obtain generalisations of that complexity into a smaller number of geographies that faithfully reflect the stories contained within the data. If a 'crisis of statistics' is to be avoided, and their value to democracy enhanced, we must ensure that they are properly analysed.

NOTES

[1] Though there is a substantial academic literature – see, for example, Smith (1973) and Knox (1975).
[2] See http://www.grantthornton.co.uk/insights/vibrant-economy-index/.
[3] The average performance of school students in two neighbouring authorities could be affected because a substantial number living in one of them attend schools in the other!
[4] Intriguingly, that variable was included in the Social Capital domain rather than that for the Natural Environment: the selection of housing affordability as an indicator of Social Capital is also intriguing!
[5] Social trust is one of the variables for which the source was a survey data set and it may be that for some, if not many, places the number of respondents was both small and unrepresentative,
[6] In fact the correlation is only 0.579, whose squared value indicates that only one-third of the variation in one of the variables can be accounted for by the variation in the other. This illustrates an issue with the interpretation of factor loadings. Two high loadings on the same factor (0.91 and 0.86) may not indicate very close correlation between the two variables – as the visual representations in Johnston (1978) illustrate.
[7] The correlation between the two was only 0.366, however.
[8] Because three of the four Natural Environment variables loaded strongly on the first factor for this group (Table) the Institute's composite index for that domain will be dominated by those three and refer to issues relating to pollution and waste disposal.

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TABLE 1: LOADINGS FOR THE VARIABLES IN EACH DOMAIN ON THE FIRST FACTOR DERIVED FROM A PRINCIPAL COMPONENTS FACTOR ANALYSIS OF THOSE VARIABLES, WITH THE ASSOCIATED EIGENVALUES AND PERCENTAGES OF THE DOMAIN VARIATION ACCOUNTED FOR.

Economic Quality	
Unemployment	0.92
Long Term Unemployment	0.87
Child Poverty	0.85
Living Comfortably	0.60
Job Satisfaction	0.28
Median Annual Earnings	0.33
GVA Growth	0.37
Eigenvalue	3.02 (43%)
Educational Attainment	
GCSE Performance	0.72
GCSE Core Subjects	0.82
No Qualifications	0.58
Truancy	0.66
Eigenvalue	1.96 (49%)
Safety and Security	
Safe Walking	0.53
Community Safety	0.74
Road Deaths	-0.48
Violent Crime	0.74
Theft	0.86
Eigenvalue	2.34 (47%)
Natural Environment	
Waste Generated	-0.58
Landfill	-0.68
Air Pollution	0.88
Protected Land	0.41
Eigenvalue	1.73 (43%)

Business Environment	
Broadband Speed	0.91
Superfast Availability	0.89
Business Survival	-0.48
Business Creation	0.49
Logistics Index	0.66
Eigenvalue	2.51 (50%)
Health	
Life Expectancy at Birth	0.96
Life Expectancy at 65	0.94
Anxiety	0.19
Wellbeing	0.41
Cancer Mortality	0.81
Premature Cardiovascular Mortality	0.90
Obesity	0.61
Infant Mortality	0.24
Health Satisfaction	0.51
Smoking Rate	0.56
Eigenvalue	4.47 (45%)
Social Capital	
Recycling Rate	0.27
Volunteering	-0.58
Voter Turnout	0.41
Social Trust	0.67
Housing Costs	0.30
Housing Affordability	0.56
Friendship Support	0.59
Family Support	0.67
Eigenvalue	2.21 (28%)

TABLE 2: RESULTS OF PRINCIPAL COMPONENTS FACTOR ANALYSES OF THE VARIABLES IN EACH DOMAIN, GIVING THE NUMBER OF VARIABLES IN EACH (NV), THE SIZE OF EACH OF THE EIGENVALUES GREATER THAN 1.0, AND THE PERCENTAGE OF THE TOTAL VARIATION WITHIN THE DOMAIN ACCOUNTED FOR BY THOSE FACTORS.

	NV	Eigen1	Eigen2	Eigen3	Variation %
Economic Quality	7	3.0	1.3		52.0
Business Environment	5	2.5			50.0
Educational Attainment	4	2.0	1.0		74.4
Health	10	4.5	1.4		59.0
Safety & Security	5	2.3			46.7
Social Capital	8	2.2	1.3	1.1	57.5
Natural Environment	4	1.7	1.1		69.6

TABLE 3: LOADINGS ON THE EXTRACTED FACTOR, AFTER ROTATION, FOR THE VARIABLES IN EACH DOMAIN

Loadings on Factor	1	2
Economic Quality		
Unemployment	0.89	0.32
Long Term Unemployment	0.81	0.46
Child Poverty	0.86	0.15
Living Comfortably	0.67	-0.16
Job Satisfaction	0.44	-0.57
Median Annual Earnings	0.17	0.71
GVA Growth	0.24	0.57
Business Environment		
Broadband Speed	0.91	0.02
Superfast Availability	0.89	-0.02
Business Survival	-0.37	0.77
Business Creation	0.57	0.57
Logistics Index	0.63	-0.18
Educational Attainment		
GCSE Performance	0.91	0.16
GCSE Core Subjects	0.86	0.39
No Qualifications	0.16	0.87
Truancy	0.34	0.78

	1	2
Health		
Life Expectancy at Birth	0.95	0.12
Life Expectancy at 65	0.93	0.13
Anxiety	0.07	0.84
Wellbeing	0.34	0.60
Cancer Mortality	0.78	0.21
Cardiovascular Mortality	0.88	0.28
Obesity	0.67	-0.36
Infant Mortality	0.29	-0.37
Health Satisfaction	0.53	-0.08
Smoking Rate	0.57	-0.05
Safety and Security		
Safe Walking	0.34	-0.63
Community Safety	0.67	-0.53
Road Deaths	-0.17	0.86
Violent Crime	0.87	-0.13
Theft	0.89	-0.38
Natural Environment		
Waste Generated	-0.72	0.13
Landfill	-0.73	-0.09
Air Pollution	0.71	0.46
Protected Land	-0.06	0.96

Loading on Factor	1	2	3
Social Capital			
Recycling Rate	0.12	0.66	-0.03
Volunteering	-0.24	0.10	-0.83
Voter Turnout	0.36	-0.26	0.50
Social Trust	0.42	0.53	0.43
Housing Costs	0.07	0.66	0.07
Housing Affordability	0.04	0.28	0.77
Friendship Support	0.86	0.09	0.12
Family Support	0.80	0.21	0.23

TABLE 4: LOADINGS FROM THE PRINCIPAL COMPONENTS FACTOR ANALYSES OF THE LEGATUM INSTITUTE INDICES FOR THE SEVEN DOMAINS SHOWING FOR A SINGLE-FACTOR AND A THREE-FACTOR SOLUTION FROM ANALYSES OF THE SEVEN COMPOSITE INDICES

Solution	Single-Factor	Three-Factor (Rotated)		
Loadings on Factor	1	1	2	3
Economic Quality	0.86	0.86	-0.32	-0.00
Business Environment	-0.18	0.19	0.70	-0.34
Education	0.72	0.84	-0.50	0.02
Health	0.79	0.90	-0.06	0.13
Safety and Security	0.59	0.26	-0.85	-0.01
Social Capital	0.51	0.19	-0.80	0.02
Natural Environment	0.27	0.14	-0.11	0.96

TABLE 5: LOADINGS FROM PRINCIPAL COMPONENTS FACTOR ANALYSES OF THE SCORES ON THE FACTORS EXTRACTED FROM THE ANALYSES OF THE VARIABLES IN EACH DOMAIN IN TABLE 3

	Loadings on Factor			
	1	2	3	4 .
Economic Quality 1	0.63	-0.55	0.31	-0.36
Economic Quality 2	-0.27	-0.65	-0.11	0.39
Business Environment 1	-0.76	-0.10	0.07	0.54
Business Environment 2	0.14	-0.78	0.08	-0.06
Education 1	0.01	-0.30	0.73	0.01
Education 2	0.09	-0.83	0.09	-0.12
Health 1	0.02	-0.87	0.26	-0.15
Health 2	0.57	-0.02	-0.15	-0.43
Safety & Security 1	0.86	-0.07	0.35	-0.28
Safety & Security 2	-0.47	0.17	-0.10	0.76
Social Capital 1	0.22	0.18	0.77	-0.32
Social Capital 2	0.66	-0.02	-0.04	-0.31
Social Capital 3	0.30	0.84	0.23	0.16
Natural Environment 1	0.66	0.52	0.36	-0.01
Natural Environment 2	0.30	0.01	0.16	-0.82

TABLE 6: CORRELATIONS BETWEEN THE FOUR FACTORS IDENTIFIED ABOVE AND THE SEVEN DOMAIN INDICES PLUS THE COMPOSITE INDEX ACROSS ALL DOMAINS

	Economy	Business	Education	Health	Safety	Capital	Environment	Composite
Factor 1	0.42	-0.62	0.08	0.15	0.80	0.64	-0.02	0.33
Factor 2	-0.72	-0.23	-0.72	-0.83	0.02	0.12	-0.16	-0.74
Factor 3	0.30	0.11	0.49	0.26	0.37	0.46	-0.02	0.48
Factor 4	-0.18	0.50	-0.07	-0.23	-0.23	-0.43	-0.74	-0.33

TABLE 7: THE LOCAL AUTHORITIES WITH THE TOP TEN AND BOTTOM TEN SCORES ON THE FOUR VARIABLES IN THE EDUCATION DOMAIN, ON THE LEGATUM COMPOSITE EDUCATION INDEX, AND THE SCORES ON THE TWO FACTORS DERIVED FROM THE PRINCIPAL COMPONENTS FACTOR ANALYSIS OF THOSE FOUR VARIABLES IN TABLE 3

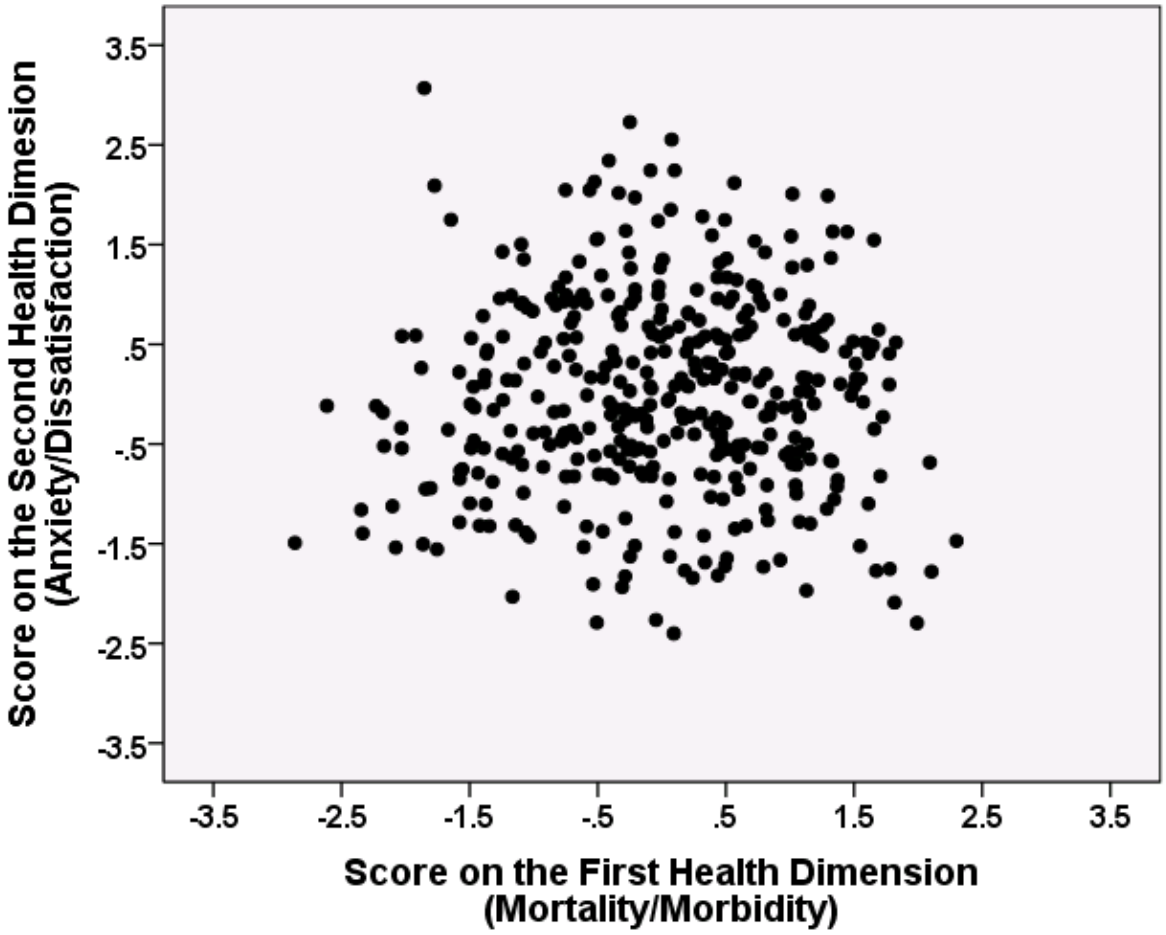
GCSE Performance	GCSE Core Subjects	No Qualifications	Truancy
Top ten			
Neath Port Talbot	East Renfrewshire	Exeter	Flintshire
Monmouthshire	East Dunbartonshire	Fareham	Trafford
Ceredigion	Kingston upon Thames	Shetland Islands	Gwynedd
Vale of Glamorgan	Lisburn and Castlereagh	Tonbridge and Malling	Rutland
Swansea	Fermanagh & Omagh	Test Valley	Wokingham
Gwynedd	Mid & East Antrim	Bath & NE Somerset	Hambleton
Powys	Causeway Coast & Glens	Charnwood	Harrogate
East Renfrewshire	Trafford	Taunton Deane	Shropshire
Rhondda Cynon Taff	Shetland Islands	South Cambridgeshire	Craven
Carmarthenshire	Barnet	South Derbyshire	Central Bedfordshire
Bottom ten			
Peterborough	Kingston upon Hull	Armagh…	Glasgow
Derby	Merthyr Tydfil	Forest Heath	North Ayrshire
Glasgow	Wrexham	Causeway Coast & Glens	South Ayrshire
Isle of Wight	Middlesbrough	Walsall	East Ayrshire
Kingston-upon-Hull	Bradford	Antrim & Newtonabbey	Inverclyde
Clackmannanshire	Clackmannanshire	Blaenau Gwent	Clackmannanshire
Bradford	Nottingham	Wolverhampton	Dundee
Blackpool	Blackpool	Mid Ulster	North Lanarkshire
Nottingham	Blaenau Gwent	Derry and Strabane	Renfrewshire
Knowsley	Knowsley	Sandwell	West Dunbartonshire

Legatum Education Score	First Education Factor	Second Education Factor
Top Ten		
East Renfrewshire	East Renfrewshire	Exeter
East Dunbartonshire	East Dunbartonshire	Wokingham
Shetland Islands	Fermanagh & Omagh	Rutland
Kingston upon Thames	Lisburn & Castlereagh	Shetland Islands
Trafford	Kingston upon Thames	Bath & NE Somerset
Sutton	Causeway Coast & Glens	Chiltern
Monmouthshire	Mid & East Antrim	Trafford
Wokingham	Monmouthshire	St Albans
Rutland	Vale of Glamorgan	Maidenhead
Chiltern	Sutton	Fareham
Bottom Ten		
Nottingham	Stoke-on-Trent	Sandwell
Dundee	Glasgow	Inverclyde
Blackpool	Derby	Renfrewshire
Bradford	Isle of Wight	Causeway Coast & Glens
Clackmannanshire	Kingston-upon-Hull	Knowsley
Glasgow	Bradford	Antrim & Newtonabbey
Stoke-on-Trent	Clackmannanshire	East Ayrshire
Sandwell	Nottingham	North Lanarkshire
West Dunbartonshire	Blackpool	Derry & Strabane
Knowsley	Knowsley	West Dunbartonshire

TABLE 8: THE LOCAL AUTHORITIES WITH THE TOP TEN AND BOTTOM TEN SCORES ON THE *LEGATUM UK PROSPERITY INDEX*, AND THE SCORES ON THE THREE FACTORS DERIVED FROM THE PRINCIPAL COMPONENTS FACTOR ANALYSIS OF THE SEVEN LEGATUM DOMAIN INDICES IN TABLE 5

UK Prosperity Index	Legatum Factor 1	Legatum Factor 2	Legatum Factor 3
Top Ten			
Waverley	St Albans	Westminster	Lewes
Mole Valley	Richmond upon Thames	Camden	Rother
Winchester	Waverley	Kensington & Chelsea	Copeland
St Albans	Wokingham	Tower Hamlets	New Forest
Chiltern	Winchester	Hackney	Brighton & Hove
South Oxfordshire	Mole Valley	Lambeth	North Devon
Mid Sussex	Hart	Brent	Barrow-in-Furness
East Hampshire	East Hertfordshire	Islington	West Devon
East Dunbartonshire	Woking	Hammersmith & Fulham	East Devon
Guildford	Chiltern	Haringey	Tower Hamlets
Bottom Ten			
Stoke-on-Trent	Sandwell	Angus	Cardiff
Liverpool	Liverpool	Dumfries & Galloway	Trafford
Barking & Dagenham	Blackpool	East Lothian	Peterborough
Blaenau Gwent	East Ayrshire	West Somerset	Telford & Wrekin
Sandwell	Nottingham	Merthyr Tydfil	North Lincolnshire
Glasgow	Glasgow	Moray	East Renfrewshire
Nottingham	Derry & Strabane	Orkney Islands	East Dunbartonshire
Middlesbrough	Blaenau Gwent	Shetland Islands	Sutton
Blackpool	Middlesbrough	Highland	Windsor & Maidenhead
Kingston-upon-Hull	Kingston-upon-Hull	Eilean Siar	Wakefield

FIGURE 1: SCATTER-GRAPH SHOWING THE RELATIONSHIP BETWEEN THE FACTOR SCORES FOR INDIVIDUAL LOCAL AUTHORITIES ON THE TWO HEALTH DOMAIN FACTORS



Appendix: the Seven Domains and the Variables

Variable Name (used in the text)	Full description
Domain 1: Economic Quality	
Unemployment	Per cent of the working age population unemployed
Long Term Unemployment	Per cent of the working age population who have been claiming unemployment benefit for more than twelve months
Child poverty	Per cent of children in households with equivalised incomes less than 60 per cent of the median
Living comfortably	Per cent of survey respondents who are living comfortably on their current income
Job satisfaction	Per cent of survey respondents who are somewhat, mostly or completely satisfied with their job
Median annual earnings	Median annual individual earnings
GVA growth	Percentage growth in GVA (gross value added) over five years
Domain 2: Business Environment	
Broadband speed	Average broadband speed (Mbps)
Superfast availability	Per cent with access to superfast broadband (greater than 24Mbps)
Business survival	Per cent of business starts still trading after five years
Business creation	New business creations per 1000 people
Logistics index	Index of access to trunk roads, rail, ports and airports
Domain 3: Educational attainment	
GCSE performance	Per cent students receiving five GCSEs of equivalent at A*-C
GCSE core subjects	Per cent students receiving five GCSEs of equivalent at A*-C # in core subjects
No qualifications	Per cent of population with no qualifications
Truancy	Per cent unauthorised absences from state secondary schools
Domain 4: Health	
Life expectancy at birth	Life expectancy at birth
Life expectancy at 65	Life expectancy at age 65
Anxiety	Responses to question ‘how anxious did you feel yesterday?’
Wellbeing	Responses to question ‘to what extent do you feel the things you do in life are worthwhile’
Cancer mortality	Age standardised cancer (excluding non-melanoma skin cancer) rate per 100,000
Premature cardiovascular mortality	Age standardised cardiovascular mortality rate pre age 75 per 100,000
Obesity	Per cent of the population obese (BMI of 30 or above)
Infant mortality	Deaths under the age 1 per 1000 live births
Health satisfaction	Per cent of respondents satisfied with their health
Smoking rate	Per cent of respondents who smoke regularly
Domain 5: Safety & Security	
Safe walking	Per cent of respondents who feel safe walking at night
Community safety	Per cent of respondents who have felt unsafe in public in last 12 months
Road deaths	People killed or seriously injured in a road traffic collision per 100,000 people
Violent crime	Violent crimes recorded per 10,000 people
Theft	Number of thefts per 10,000 people
Domain 6: Social Capital	
Recycling rate	Per cent of waste that is recycled, composted or reused
Volunteering	Per cent of respondents who have volunteered within the last month

Voter turnout	Per cent of registered electors who voted at the last scheduled local council elections (excluding general election years)
Social trust	Per cent who think that people in general can be trusted
Housing costs	Per cent of respondents who have struggled to pay their mortgage or rent in the past 12 months
Housing affordability	Average house price/median annual earnings
Friendship support	Per cent of respondents who feel they can rely on their friends if they have a problem
Family support	Per cent of respondents who feel they can rely on their family if they have a problem
Domain 7: Natural Environment	
Waste generated	Waste per head generated per year (kgs)
Landfill	Per cent of local authority managed waste tonnage sent to landfill and tonnage non EfW incinerated
Air pollution	population-weighted annual mean anthropogenic PM2.5 concentration (ugm-3)
Protected land	Per cent of land area that has statutory protection.

Most of the variables are derived from Office of National Statistics published tabulations; those referring to per cent of respondents are from survey data, in most cases from Understanding Society. For further details see the Legatum Institute's *Guide to the UK Prosperity Index*, available at http://uk.prosperity.com/docs/2016/2016UKProsperityIndexMethodology.pdf.